ARMY RESEARCH LABORATORY

Data Transfer Report - 30-mm Enhanced Alternate High-Energy Propellant Program (EAHEP): Evaluation of the Performance of an RDX-Based ARDEC-7994 Propellant and the Effect of Two Different Slug Projectile Designs

by Melvin B. Ridgley, Sr.
and Joseph W. Colburn

ARL-TN-114 May 1999

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Melvin B. Ridgley, Sr., and Joseph W. Colburn
Weapons and Materials Research Directorate, ARL

Abstract

The main test objectives were: (1) to promote the evaluation of novel high-energy gun propellants that hold the promise of enhanced performance from existing tank and artillery systems and (2) to provide a facility that can assess the interior ballistic performance characteristics of small quantities of these propellants. Test No. 61 was an instrumentation checkout round, using M30 propellant and a 300-g projectile. Test Nos. 62–65 each utilized a 250-g projectile and 100 g of ARDEC-7994 propellant. Test Nos. 62 and 64 utilized the "Type-1" projectile (see Figure 1). This projectile type has a depressed obturator that snaps on to the rear of the projectile. This design creates an additional 3 cm^3 of initial chamber volume and allows for more of a balspoon seal effect. Test Nos. 63 and 65 utilized the "Type-2" projectile (see Figure 2). This projectile type has a flat-based obturator with a groove cut in the base to allow a slight balspoon seal effect. The Type-2 projectile is much less expensive than the Type-1 projectile, but a head-to-head test was desired to assess any ballistic differences resulting from the design change.

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1. Background

Measurements in support of the 30-mm Enhanced Alternate High-Energy Propellant Program (EAHEP) were taken at the U.S. Army Research Laboratory's (ARL) recording facility (Bldg. 390). These tests were conducted to evaluate the effects of time on the performance of the RDX-based ARDEC-7994 propellant. An additional objective was to evaluate the effect of two different projectile designs on the interior ballistics. This facility, the Central Data-Acquisition Network for the Ballistics and Weapons Concepts Division (BWCD) of ARL, was operated by the Experimental Ballistics Team (EBT) of the Propulsion Branch (PB). The testing was conducted in support of an ongoing Army effort to further investigate high-energy gun propellants that hold the promise of enhanced performance from existing tank and artillery systems.

2. Test Objective

As mentioned previously, the main test objectives were: (1) to promote the evaluation of novel high-energy gun propellants that hold the promise of enhanced performance from existing tank and artillery systems and (2) to provide a facility that can assess the interior ballistic performance characteristics of small quantities of these propellants. The pertinent information on the tests is detailed in the in-house branch firing request form (Appendix A). Test sample quantities, configurations, and data-acquisition inputs were as requested by the project engineer. Appendix B shows a generalized gun configuration and pressure port locations in the chamber, as well as in the barrel. In addition, it shows the range setup for the test. This report serves to formally document the data acquired during these tests for further use by the project engineer. Any technical information concerning the test setup or data should be solicited from the project engineer.

3. Summary of Results

Test No. 61 was an instrumentation checkout round, using M30 propellant and a 300-g projectile. Test Nos. 62–65 each utilized a 250-g projectile and 100 g of ARDEC-7994 propellant. Test Nos. 62 and 64 utilized the "Type-1" projectile (see Figure 1). This projectile type has a depressed obturator that snaps on to the rear of the projectile. This design creates an additional 3 cm^3 of initial chamber volume and allows for more of a balspoon seal effect. Test Nos. 63 and 65 utilized the "Type-2" projectile (see Figure 2). This projectile type has a flat-based obturator with a groove cut in the base to allow a slight balspoon seal effect. The Type-2 projectile is much less expensive than the Type-1 projectile, but a head-to-head test was desired to assess any ballistic differences resulting from the design change.

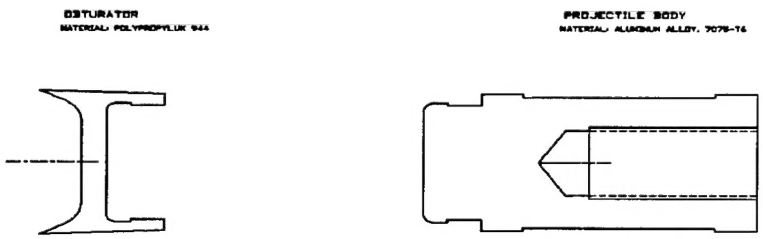

Figure 1. Type-1 Projectile and Obturator.

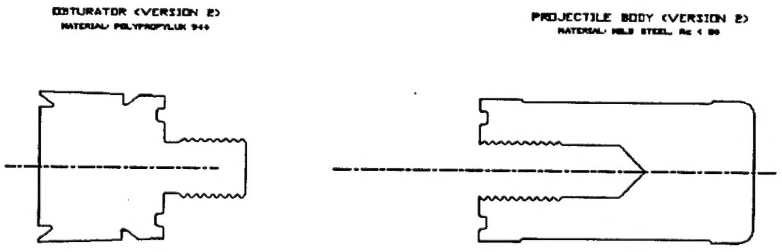

Figure 2. Type-2 Projectile and Obturator.

This report summarizes the data obtained during proof testing of the gun fixture and the initial propellant evaluation test series. Experimental firing data and ignition system parameters are tabulated in Appendix C. The instrumentation typically used to acquire data during testing are as follows:

(1) an in-bore Doppler radar (55 GHz) to measure the interior ballistic trajectory;

(2) a discriminator system to measure projectile velocity;

(3) Kistler 607C3 piezoelectric pressure transducers in gauge positions (as show in Appendix B) to measure chamber and barrel pressures;

(4) downrange breakscreens and breakscreen composite to measure velocity; and

(5) a recoil accelerometer PCB306a/1177, x-axis.

Appendix D provides an example of a standard firing program file (FPF) that includes a run summary for the 30-mm EAHEP fixture and channel description/calibration coefficients for on-line and analog tape A for the EAHEP test rounds. Due to the number of rounds fired in this series, FPFs were not included for each round; however, Appendix E provides a summary of analog tape and digital-acquisition system parameters. Twelve channels of data can be acquired on-line using BALDAS II. It is standard procedure to backup the data on an analog tape recorder for future use or in case of computer malfunction.

4. Discussion and Results

Table 1 lists the test sequences with comments appropriate to instrumentation problems encountered for each test.

Table 1. Test Sequences and Accompanying Instrumentation Remarks

Test No.	Date	Comments
61	25 August 1998	EAHEP Gun 1, M30 propellant, good data
62	26 August 1998	EAHEP Gun 1, ARDEC-7994 propellant, Type-1 projectile, good data
63	26 August 1998	EAHEP Gun 1, ARDEC-7994 propellant, Type-2 projectile, good data
64	26 August 1998	EAHEP Gun 1, ARDEC-7994 propellant, Type-1 projectile, good data
65	26 August 1998	EAHEP Gun 1, ARDEC-7994 propellant, Type-2 projectile, good data

During testing, the Building 390 recording-room staff made the following specific contributions beyond the recording of data:

(1) assisted with range setup (charged amplifiers, breakscreens, the interferometer, the range physical configuration); and

(2) gave the project engineer all of the ballistic data in the form of floppy disks (ASCII format), data plots, and FPFs at the conclusion of each test.

Appendix A:

Experimental Ballistics Team Firing Request

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EXPERIMENTAL BALLISTICS TEAM FIRING REQUEST

BRANCH REQUEST: Propulsion Branch

CONTRACTOR REQUEST: N/A

PROJECT TITLE: EAHEP Test Fixture and Propellant Evaluation

PROJECT ENGINEER(s): J. Colburn and A. Johnson

PURPOSE OF TEST: To promote the evaluation of novel high-energy gun propellants that hold the promise of enhanced performance from existing tank and artillery systems. To provide a facility that can assess the interior ballistic performance characteristics of small quantities of these propellants.

TIME FRAME REQUESTED:

LENGTH OF TEST: 25 August 1998 to 26 August 1998

(DAYS AND NUMBER OF ROUNDS): 2 Days, 5 Rounds

RANGE REQUIREMENTS:

GUN TYPE: 1.15-in (29.2 mm) Gun

PROJECTILE TYPE: Slug

CHARGE TYPE: RDX-Based ARDEC-7994

PRIMER TYPE: Benite Strand

GUN INSTRUMENTATION: Pressure Gauges in Chamber and Barrel

RANGE INSTRUMENTATION:

- Recoil Accelerometer
- Interferometer
- Discriminator/Velocity
- Video/Audio
- Breakscreens and Breakscreen Composite

INTERIOR BALLISTICIAN: J. Colburn

REVIEW OF TEST PLAN: J. Colburn

OTHER REQUIREMENTS: As Outlined by Project Engineer

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Appendix B:

Gauge Locations and Range Setup for the 30-mm EAHEP Gun Fixture Evaluation

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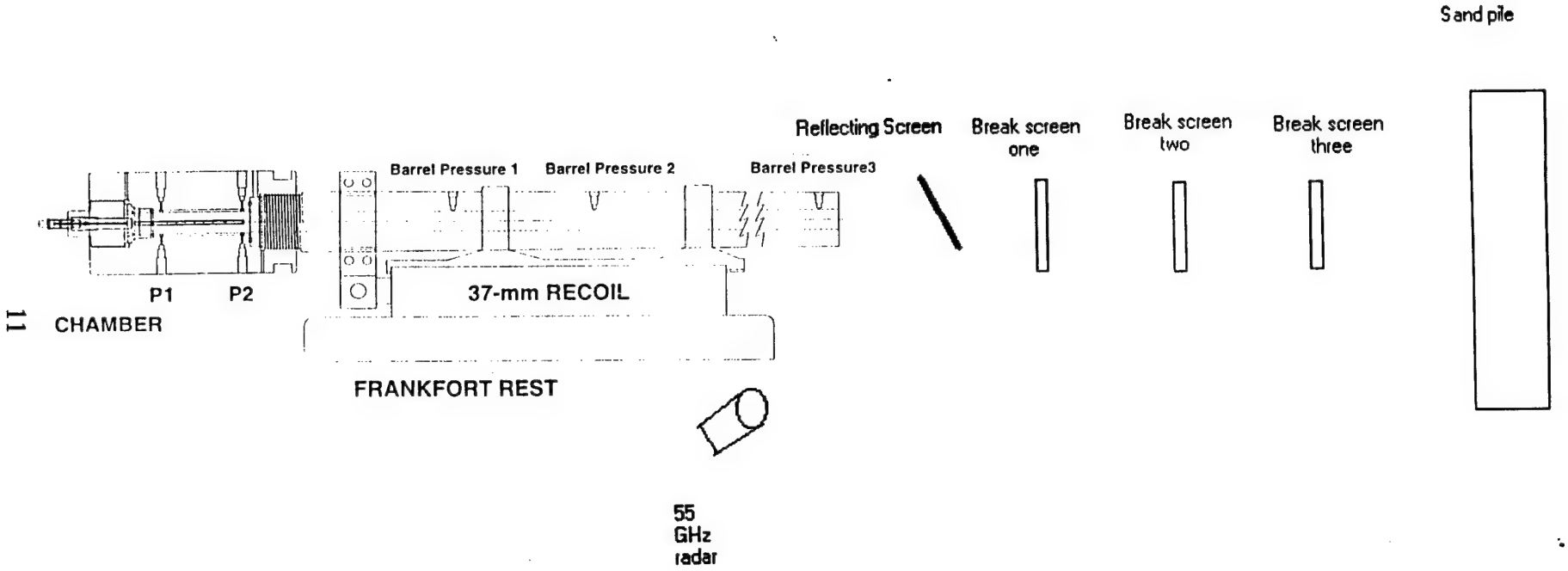

Figure B-1. Enhanced Alternate High-Energy Propellant Program (EAHEP) 30-mm Gauge Locations and Range Setup.

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Appendix C:

Tabular Data and Examples of Experimental Firing Data

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Table C-1. Tabular Data

Test No.	Peak Quasi-Static Pressure (MPa)							55-GHz Radar (m/s)
	P1L[a]	P1R[b]	P2L[a]	P2R[b]	Barrel 1	Barrel 2	Barrel 3	
61	290	276	265	263	254	214	22	928
62	386	386	288	383	353	295	35	—
63	362	350	348	354	341	291	33	1,218
64	397	353	379	371	349	289	33	1,232
65	380	353	367	365	351	289	33	1,238

[a] L = left.

[b] R = right.

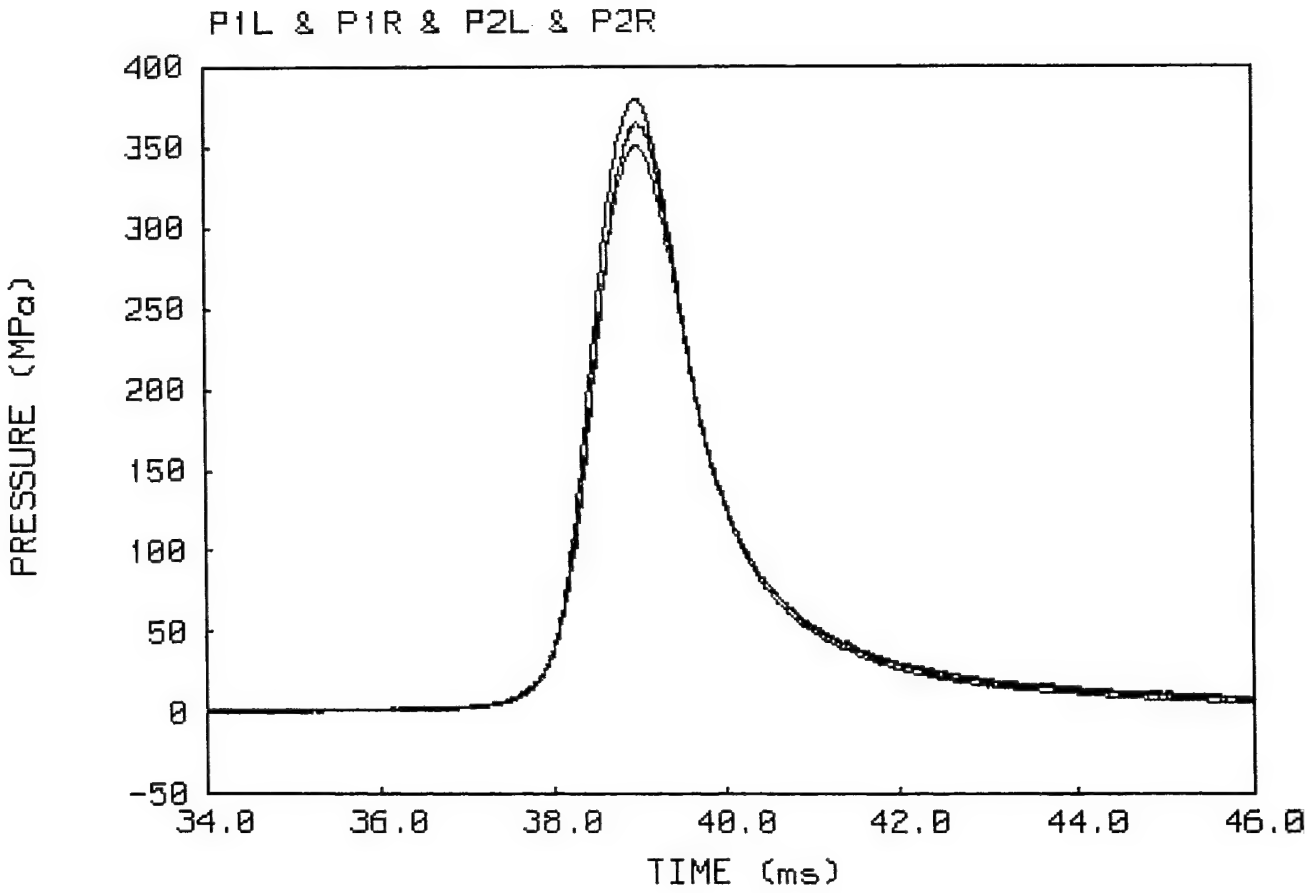

Figure C-1. Round 65: P1L, P1R, P2L, and P2R.

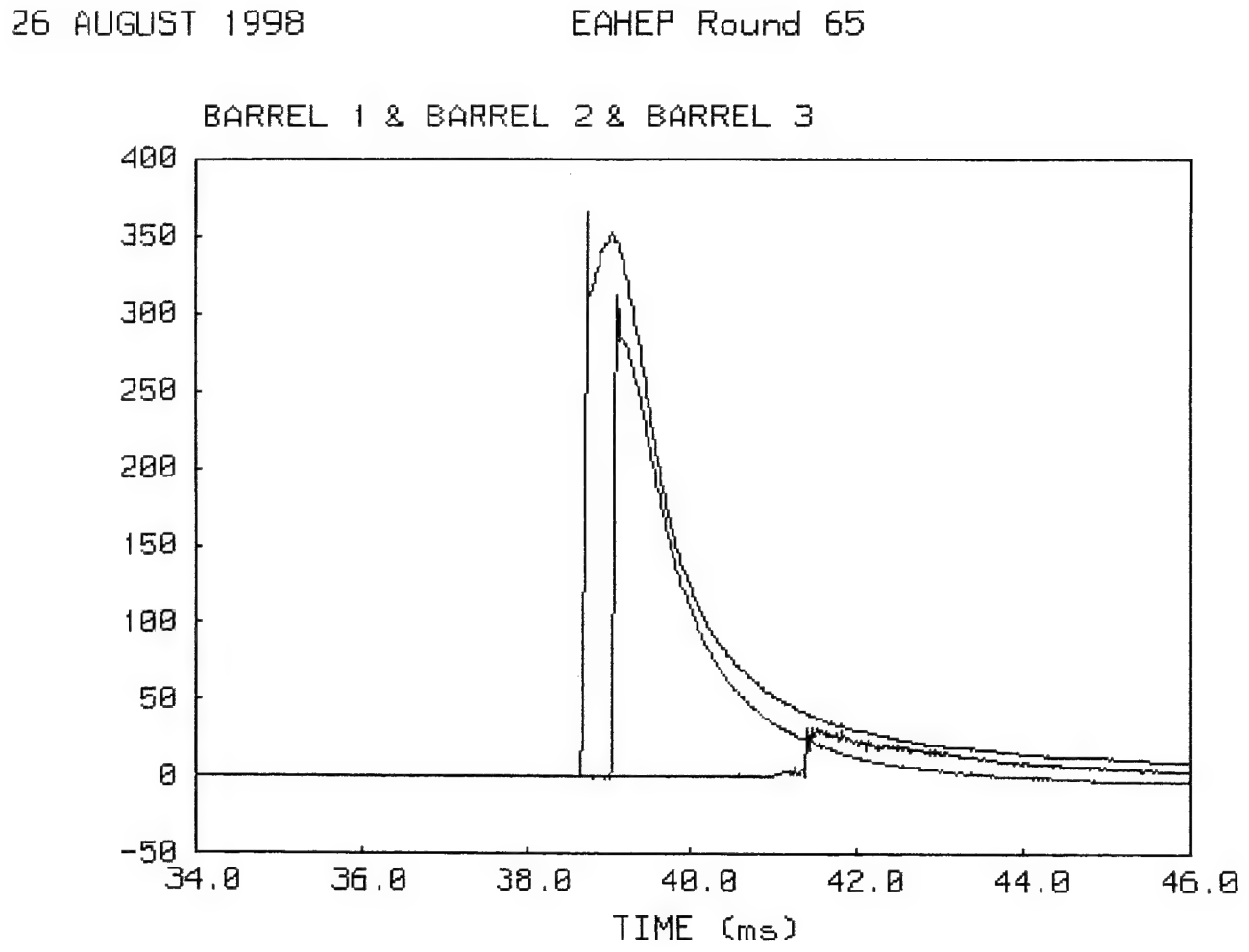

Figure C-2. Round 65: Barrel Nos. 1, 2, and 3.

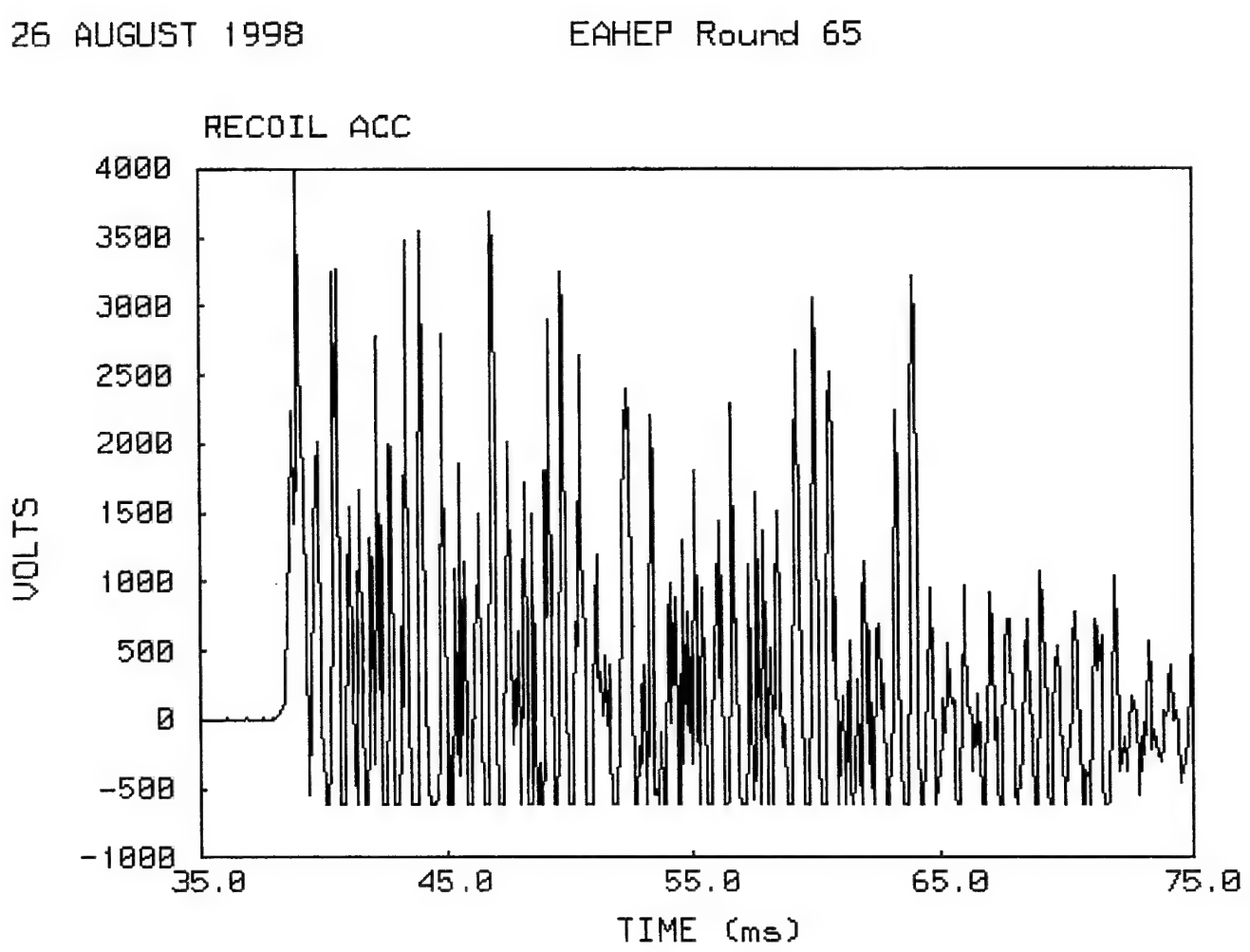

Figure C-3. Round 65: Recoil Accelerometer.

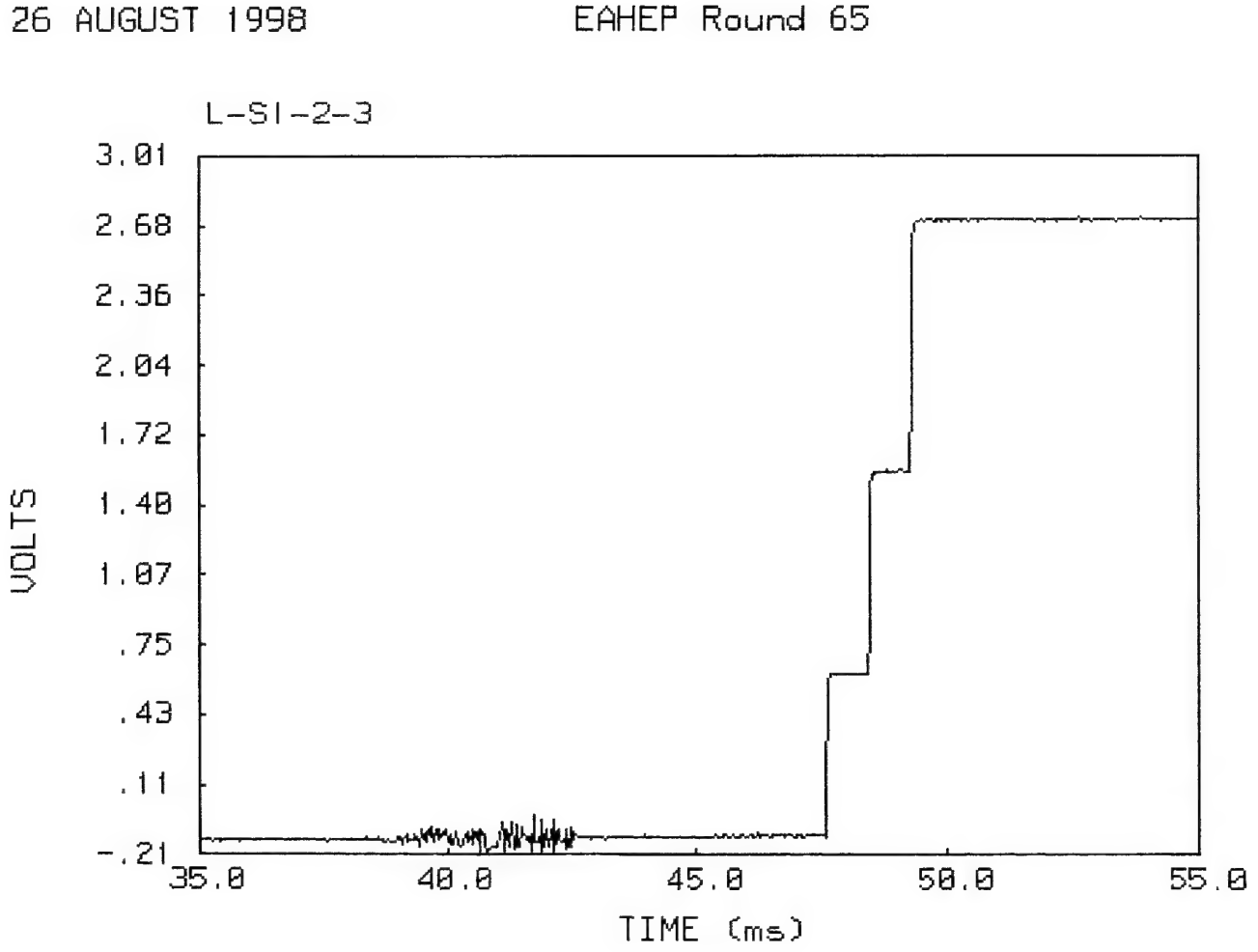

Figure C-4. Round 65: Line Screen (L-S) 1-2-3.

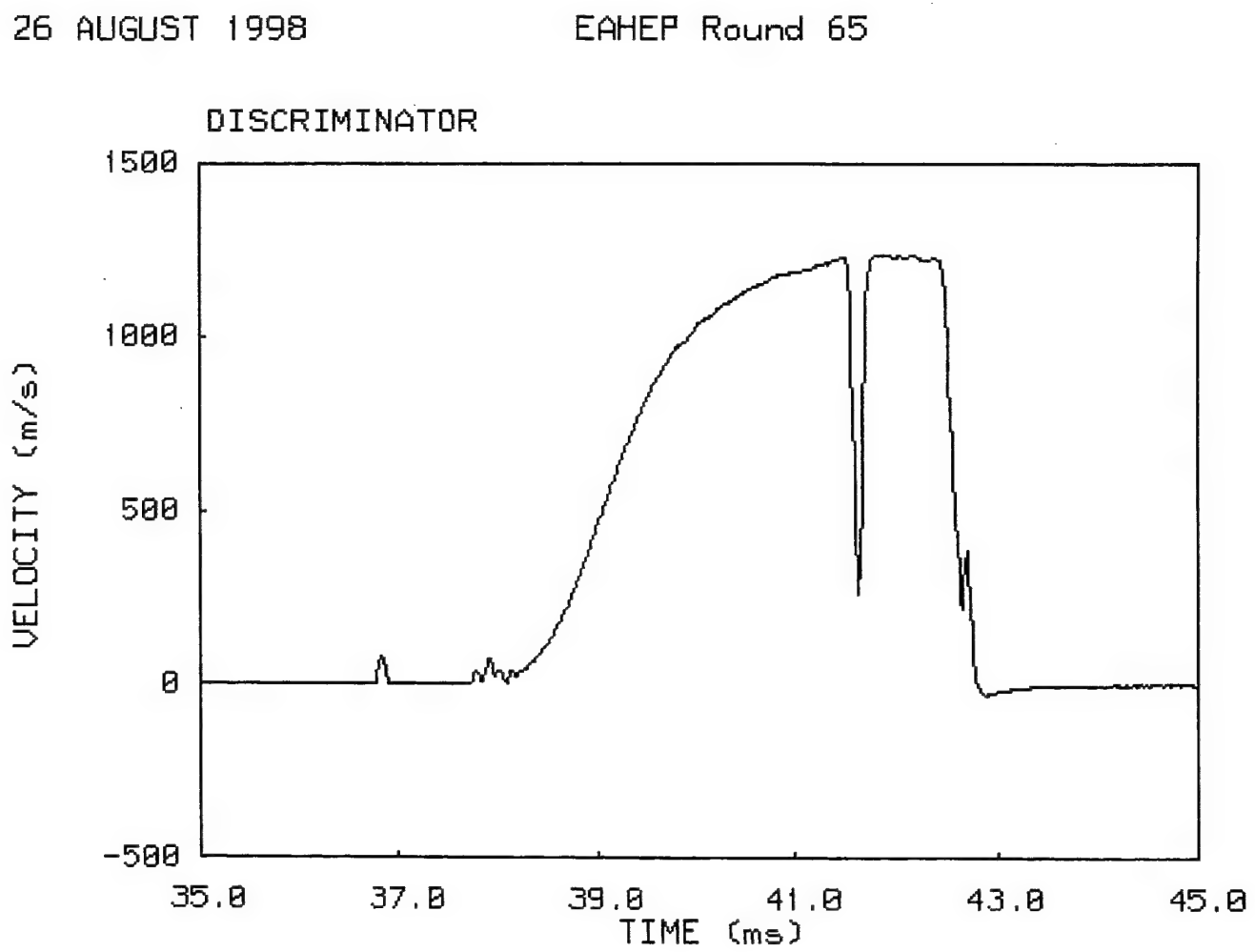

Figure C-5. Round 65: Discriminator.

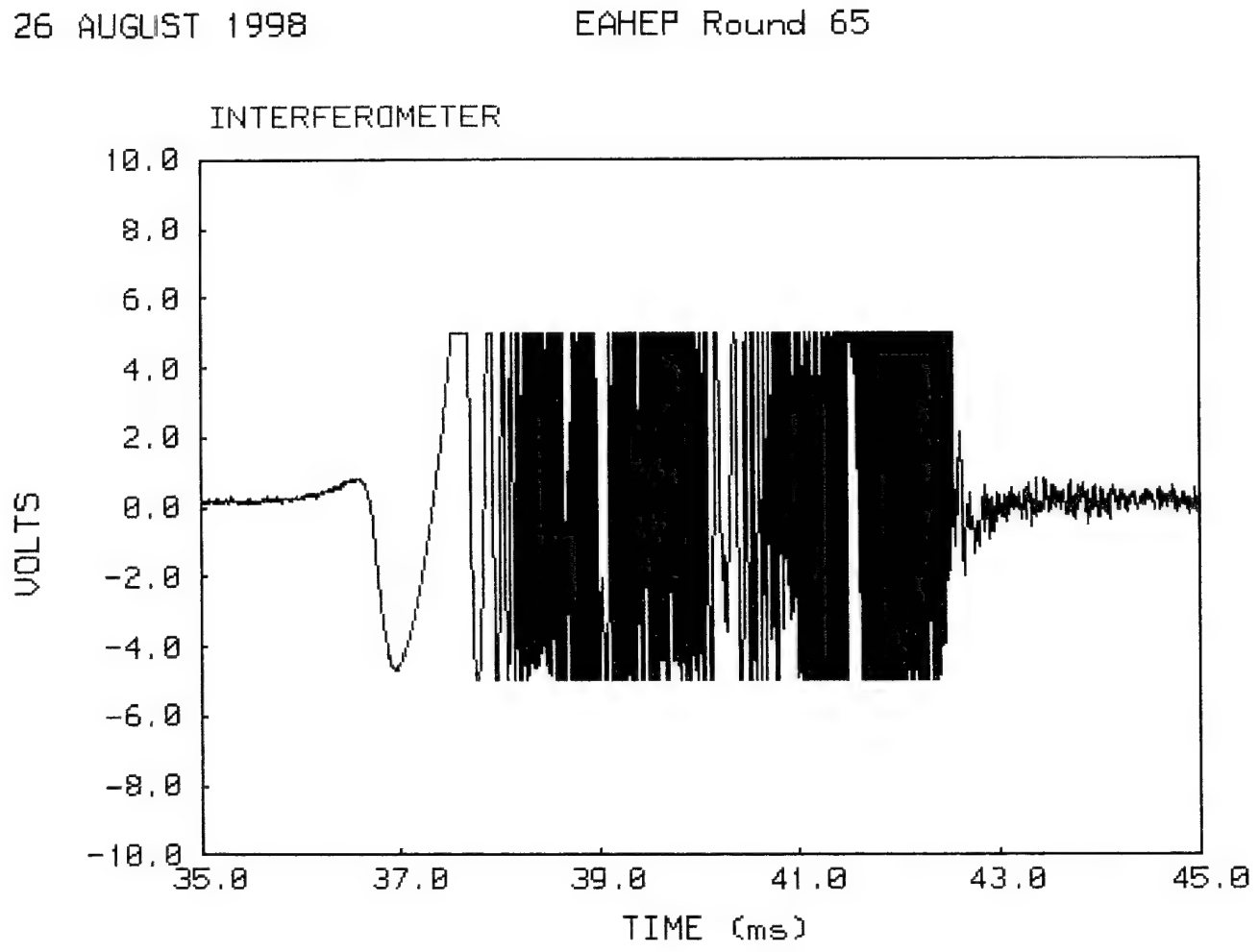

Figure C-6. Round 65: Interferometer.

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Appendix D:

Examples of Run Summary and Channel Description/Calibration Coefficients On-Line for the 30-mm EAHEP

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RUN SUMMARY FOR EAHEP - EAP ROUND 65

TEST DATA

DATE	: 26 AUGUST 1998	ENGINEER	: JUHASZ AND COLBURN
LOCATION	: R 166	OPERATOR	: T.E.R AND M.B.R
CLEARANCE	: X	GUNNERS	: COLBURN AND JOHNSON

ANALOG-TAPE PARAMETERS

REEL NUMBER	: 500	INDENT NUMBER	: 05
STATUS	: ON	SPEED CODE	: 120
START	: 0384		
STOP	:		

ENVIRONMENT

TEMPERATURE	: 20° C	DENSITY	: g/ml
BAROMETER	: mm Hg	WIND SPEED	: m/s
HUMIDITY	: %	WIND DIRECTION	: Deg.

GUN DATA

TUBE	: EAHEP-1	CALIBERS/TURN	: 999999
NUMBER	: SN 529	GROOVE DIAMETER	: 29.21 mm
TUBE ROUND NUMBER	: 1	LAND DIAMETER	: 29.21 mm
TRAVEL	: 2,670 mm	GROOVE/LAND RATIO	: 1
CHAMBER VOLUME	: 121.66 cm^3		

REMARKS : 529 USED PREVIOUSLY BY TBD

MOUNT

RECOIL TYPE	: 37 mm	MOUNT TYPE	: UNKNOWN
RECOIL SN	: UNKNOWN	MOUNT SN	: UNKNOWN
ELEVATION	: 0 mil	ASIMUTH	: 0 mil

REMARKS : BLUE MOUNT AND RECOIL

PROJECTILE

TYPE	: ALUMINUM SLUG	BAND TYPE	: POLYPROPLUX
LOT NUMBER	: 1	BAND DIAMETER	: 30.23 mm
WEIGHT	: 0.1298 kg	BAND WIDTH	: 1.9 mm
FILL	: STEEL BOLT	FUSE	: N/A
PROJECTILE TEMP.	: AMBIENT °C		

REMARKS : SLUG WITH STEEL FACE AND POLY OBTURATOR

PRIMER

PRIMER TYPE	: M52 A3 B1	WEIGHT	: N/A
LOT NUMBER	: LC-20-625	TEMPERATURE	: AMBIENT °C

REMARKS : 200-V FIRING VOLTAGE

IGNITER

IGNITER TYPE	: BENITE	WEIGHT	: 1.5 g
LOT NUMBER	:	TEMPERATURE	: AMBIENT °C

REMARKS : USING BAYONETTE IGNITER TUBE

CHARGE

CHARGE TYPE	: M30	ZONE	: RAD-PE-771-2
LOT NUMBER	: N/A	TEMPERATURE	: AMBIENT °C

REMARKS : 7-PERF M30 0.018 WEB (AVG)

CASE

CASE TYPE :LEXAN LOT NUMBER : 1

REMARKS : 0.125 in THICK

LOADING

SEATING DISTANCE : mm CHARGE STANDOFF : mm

REMARKS :

EAP ROUND 65

PROPELLANTS

NUMBER OF PROPELLANTS : 1

PROPELLANT 1

PROPELLANT TYPE	:		PERF DIAMETER	:	
LOT NUMBER	:		TEMPERATURE	:	°C
WEIGHT	:	kg	IMPETUS	:	J/kg
INNER WEB	:	mm	SPECIFIC HEAT RATIO	:	
OUTER WEB	:	mm	FLAME TEMPERATURE	:	K
LENGTH	:	mm	COVOLUME	:	cm^3/g
DIAMETER	:	mm	DENSITY	:	g/cm^3

REMARKS :

EAP ROUND 65

ADC 1

CHANNEL SIZE: 20 KB
TIME PER SAMPLE: 0.005 ms
MUX POSITION: 2
CHANNELS: 12
PRETRIGGER SIZE: 1/8
TRIGGER LEVEL: 2 V

CHANNEL	GAUGE DESCRIPTION	CALIBRATION COEFFICIENTS	
1	P1L KISTLER 607C3/C55333 Top Step: 8	CONSTANT LINEAR QUADRATIC	: -1.8134E-02 : 59.041 : -3.8545E-01
2	P1R KISTLER 607C3/C54587 Top Step: 8	CONSTANT LINEAR QUADRATIC	: -4.0484E-03 : 61.899 : -4.5280E-01
3	P2L KISTLER 607C3/C47191 Top Step: 8	CONSTANT LINEAR QUADRATIC	: 1.1991E-01 : 58.969 : -3.5226E-01
4	P2R KISTLER 607C3/C55334 Top Step: 8	CONSTANT LINEAR QUADRATIC	: -4.2308E-03 : 58.113 : -3.6975E-01
5	BARREL 1 KISTLER 607C3/C55331 Top Step: 8	CONSTANT LINEAR QUADRATIC	: 7.2705E-01 : 58.521 : -4.0855E-01
6	BARREL 2 KISTLER 607C3/C55332 Top Step: 8	CONSTANT LINEAR QUADRATIC	: -1.1505E-01 : 58.094 : -3.9972E-01
7	BARREL 3 KISTLER 607C3/C57305 Top Step: 0.5	CONSTANT LINEAR QUADRATIC	: 7.0984E-01 : 55.148 : -1.9567E-01
8	FIRING VOLTAGE (FV)	NOT CLAIBRATED	
9	RECIOL ACCELEROMETER (ACC) Top Step: 5	CONSTANT LINEAR QUADRATIC	: 0.0 : 980 : 0.0
10	LIGHT SCREEN (L-S) 1-2-3	NOT CALIBRATED	
11	DISCRIMINATOR 35 GHz Top Step: 5	CONSTANT LINEAR QUADRATIC	: 0 : 164.5 : 0
12	INTERFEROMETER 35 GHz	NOT CALIBRATED	

VELOCITY

VELOCITY DEVICE: HP COUNTER

DISTANCE 1: 0.9985 m		
ETS CHANNEL: 1	VELOCITY 1-2:	0 m/s
DISTANCE 2: 0.990 m		
ETS CHANNEL: 2	VELOCITY 2-3:	0 m/s
DISTANCE 3: 1.9885		
ETS CHANNEL: 3	VELOCITY 1-3:	0 m/s

EVENT TIMER

ETS CLOCK RATE CODE CHANNELS: 6

CHANNEL	DESCRIPTION	TIME (s)
1		0.0000
2		0.0000
3		0.0000
4		
5		
6		

TEST REMARKS

ON-LINE DATA

Appendix E:

Analog-Tape and Digital-Acquisition System Parameters

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Table E-1. Analog-Tape and Digital-Acquisition System Parameters

Round	Analog Tape	Identification	Start Footage	Tape Speed	Digital Sampling Rate		Channels	Size of Channels	
			A		On-Line (ms)	Tape Digitization (µs)	On-Line/Tape Digitization	On-Line	Digitized
61	500	01	0050-0134	120	0.010	2.5	12	16,000	16,000
62	500	02	0134-0218	120	0.005	2.5	12	20,000	16,000
63	500	03	0218-0301	120	0.005	2.5	12	20,000	16,000
64	500	04	0301-0384	120	0.005	2.5	12	20,000	16,000
65	500	05	0384-0467	120	0.005	2.5	12	20,000	16,000

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13. ABSTRACT *(Maximum 200 words)*

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